Teaching Parallel Computing Concepts with OpenMP

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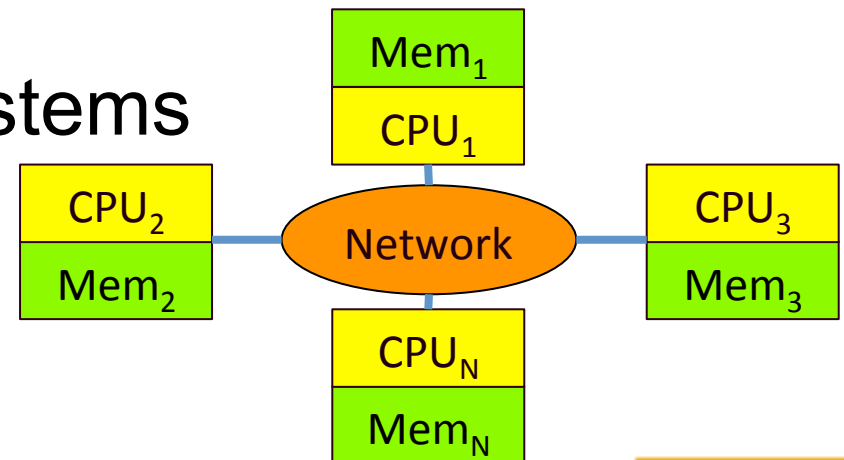
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Outline

- Welcome and Introductions
- Part I: OpenMP Patternlets
  - Introduction (Joel)
  - Connecting to remote servers (Joel)
  - The Patternlets module (Libby)
  - Self-paced exploration (You!)
- Break
- Part II: OpenMP Exemplars (Dick and Libby)
- Wrap-up: Curricular discussion (Joel)

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Hardware: A Diverse Landscape

- ## Shared-memory systems

$Core_1$	$Core_2$
$Core_3$	$Core_4$
Memory	
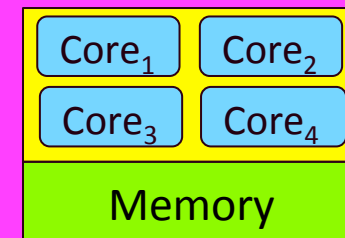
- ## Distributed-memory systems

Mem_1

CPU_1

CPU_2 — Network — CPU_3

Mem_2 — — Mem_3

CPU_N

Mem_N

- ## Hybrid systems

Shared Memory Multiprocessors

Shared-Memory Software

Lots of options: Communication via…

- Shared-Memory:
  - Shared memory languages like Java, C++11, …
  - Libraries like OpenMP, POSIX threads, …
- Message-Passing:
  - Message passing languages like Scala, Erlang, …
  - Libraries like the message passing interface (MPI)

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OpenMP

- An industry standard library for shared-memory parallel computing in C, C++, Fortran
- Consortium includes: *AMD, Cray, Fujitsu, HP, IBM, Intel, NEC, Nvidia, Oracle, Redhat, TI, …*
- *Implicit* multithreading via #pragma directives (vs. *explicit* multithreading in Pthreads)
- Many parallel programming patterns built in

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Parallel Patterns

… are strategies that practitioners have found to be frequently useful in parallel problem-solving.

- Origins: Industry-standard best practices
  - Cumulative wisdom from decades of experience

- When solving problems, experts *think* in patterns
  - The more we can help our students master patterns, the more like experts they will be.

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A Few Sample Patterns

- *Algorithmic* Strategies:
  - Data Decomposition, Task Decomposition, …

- *Implementation* Strategies:
  - SPMD, Fork-Join, Master-Worker, Parallel Loop, …

- *Concurrent Execution* Strategies:
  - Barrier, Mutual Exclusion, Message Passing, Broadcast, Reduction, Scatter, Gather, …

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Terminology: *Patternlets*

… are minimalist, scalable, complete programs, each illustrating one or more parallel patterns:

- *Minimalist* to help students understand the pattern by eliminating non-essential details
- *Scalable* so that students can vary the number of threads and see the pattern's behavior change
- *Complete* so that:
  – Instructors can use them in a 'live coding' lecture
  – Students can explore them in a hands-on exercise

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Terminology: *Exemplars*

… are programs that use one or more patterns to solve a 'real world' problem.

Exemplars let students see how the pattern is useful in a more meaningful context

A *patternlet* is useful for *introducing* students to a pattern; an *exemplar* is useful for helping students see how & why a pattern is *relevant*.

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- Welcome and Introductions
- Part I: OpenMP Patternlets ✔
- Break ✔
- Part II: OpenMP Exemplars ✔
  - Area under the curve (Dick)
  - Drug Design (Dick)
  - Pandemic (Libby)
  - Self-paced exploration of Exemplars
- Wrap-up: Curricular discussion (Joel) ✔

Thank you!

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